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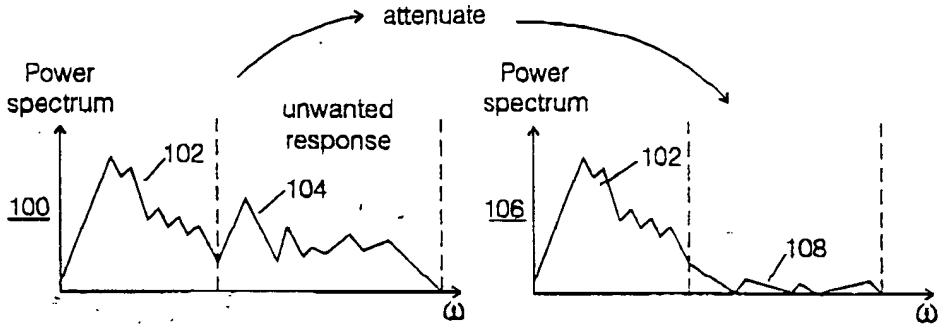


Fig. 1

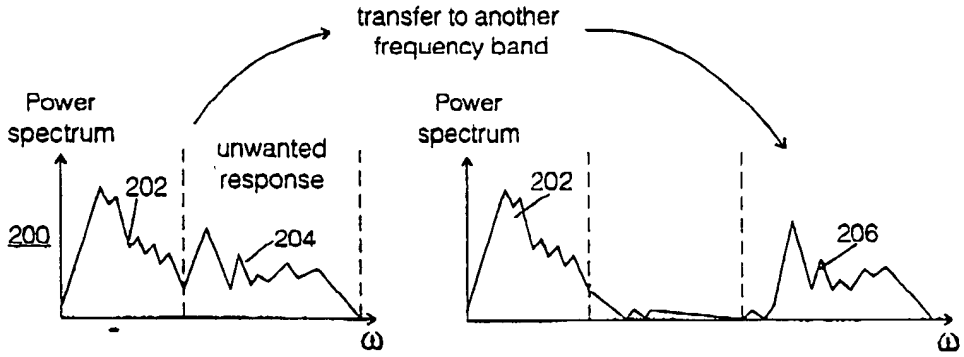


Fig. 2

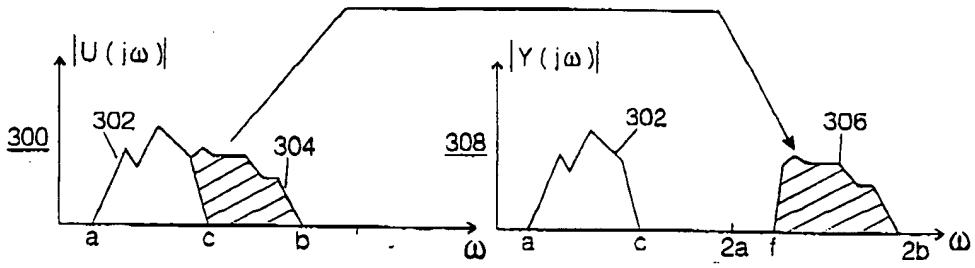
|U ( jω )|
300
302
304
a
c
b
ω
|Y ( jω )|
308
302
306
a
c
2a
f
2b
ω

Fig. 3

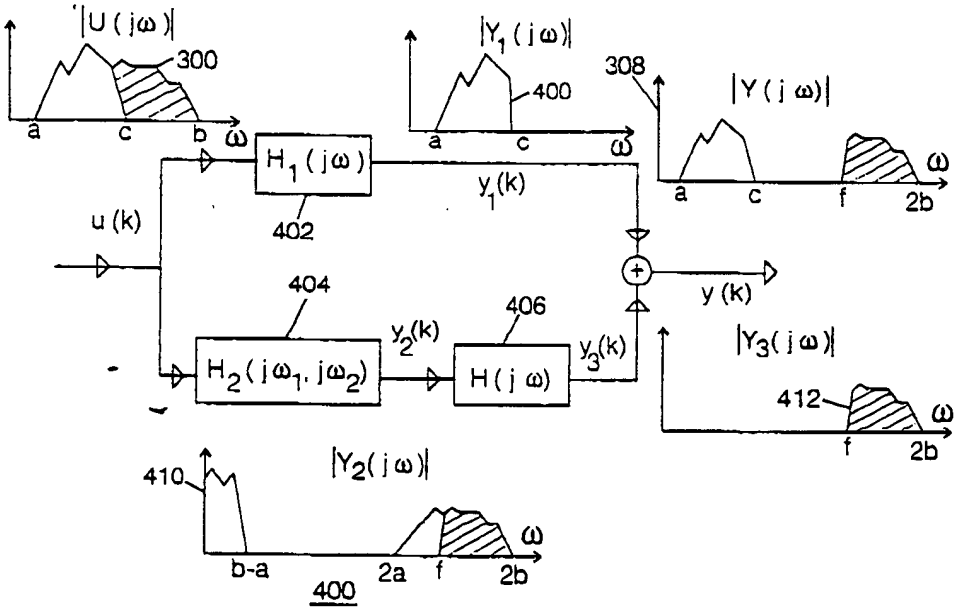
|U ( jω )|
300
a
c
b
ω
H1 ( jω )
402
|Y1 ( jω )|
400
a
c
ω
y1(k)
308
|Y ( jω )|
a
c
f
2b
ω
u (k)
404
H2 ( jω1, jω2)
y2(k)
406
H ( jω )
y3(k)
y (k)
|Y3( jω )|
412
f
2b
ω
410
|Y2( jω )|
b-a
2a
f
2b
ω
400

Fig. 4

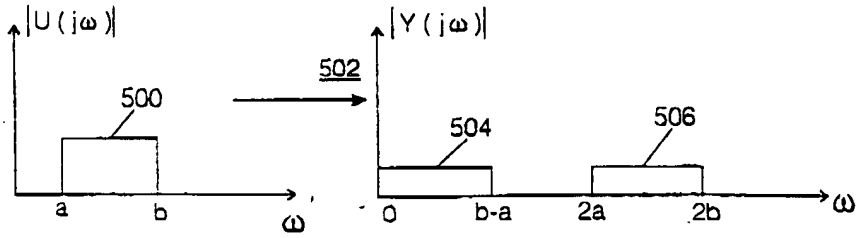


Fig. 5

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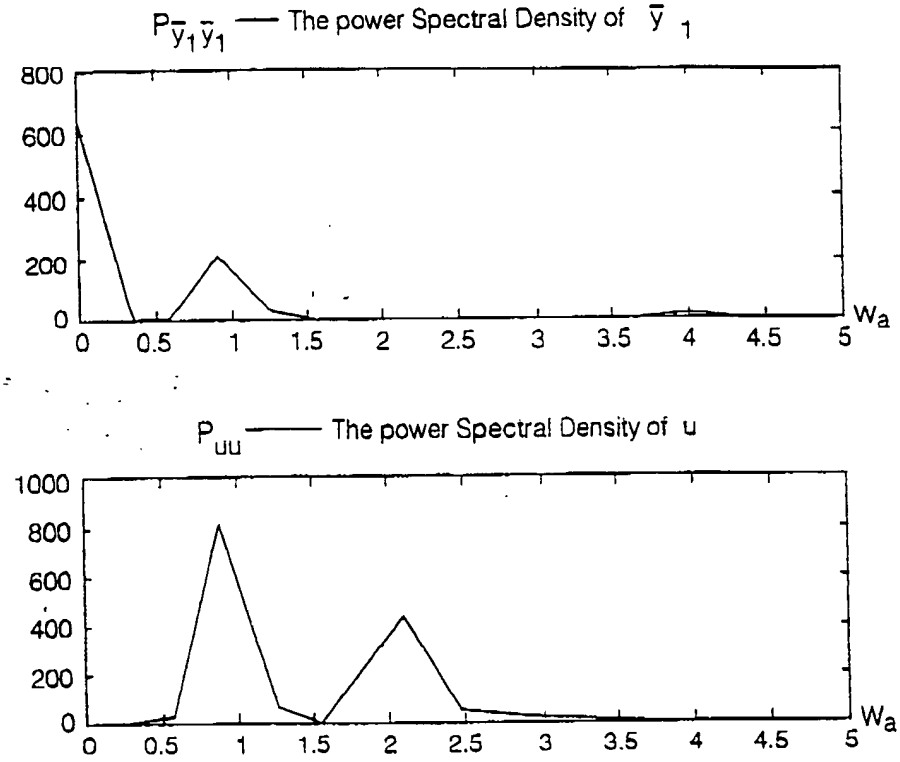


Fig. 6

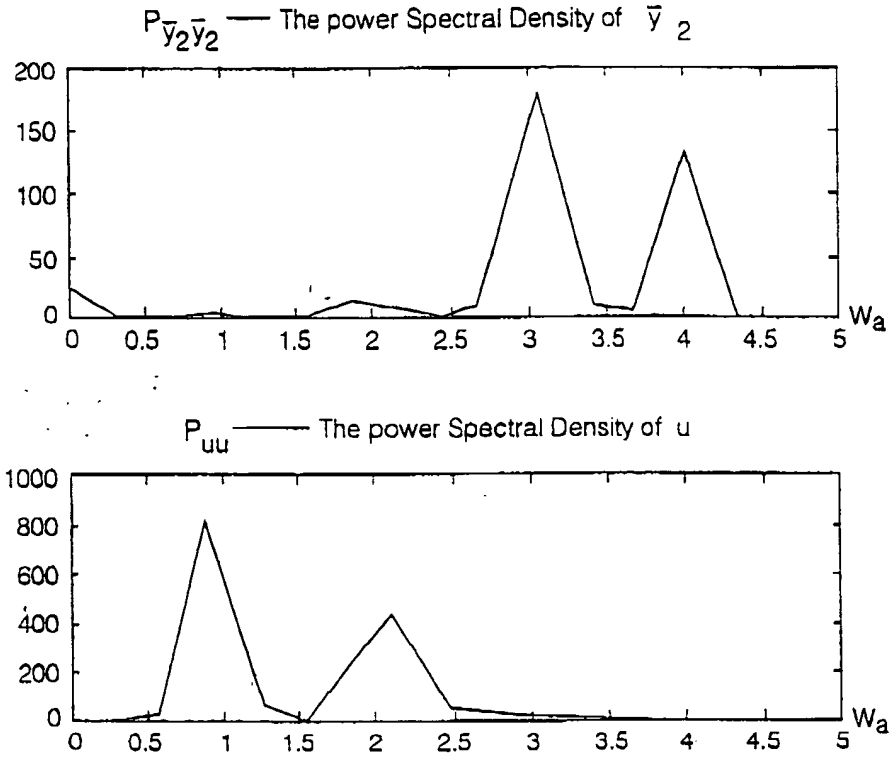
$P_{\bar{y}_2\bar{y}_2}$ — The power Spectral Density of $\bar{y}_2$
200
150
100
50
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Wa
$P_{uu}$ — The power Spectral Density of u
1000
800
600
400
200
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Wa

Fig. 7

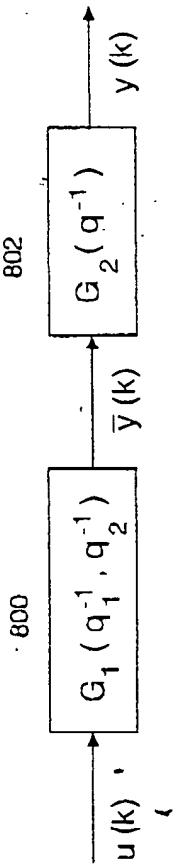
u(k)
800
$G_1(q_1^{-1}, q_2^{-1})$
$\bar{y}(k)$
802
$G_2(q^{-1})$
y(k)

Fig. 8

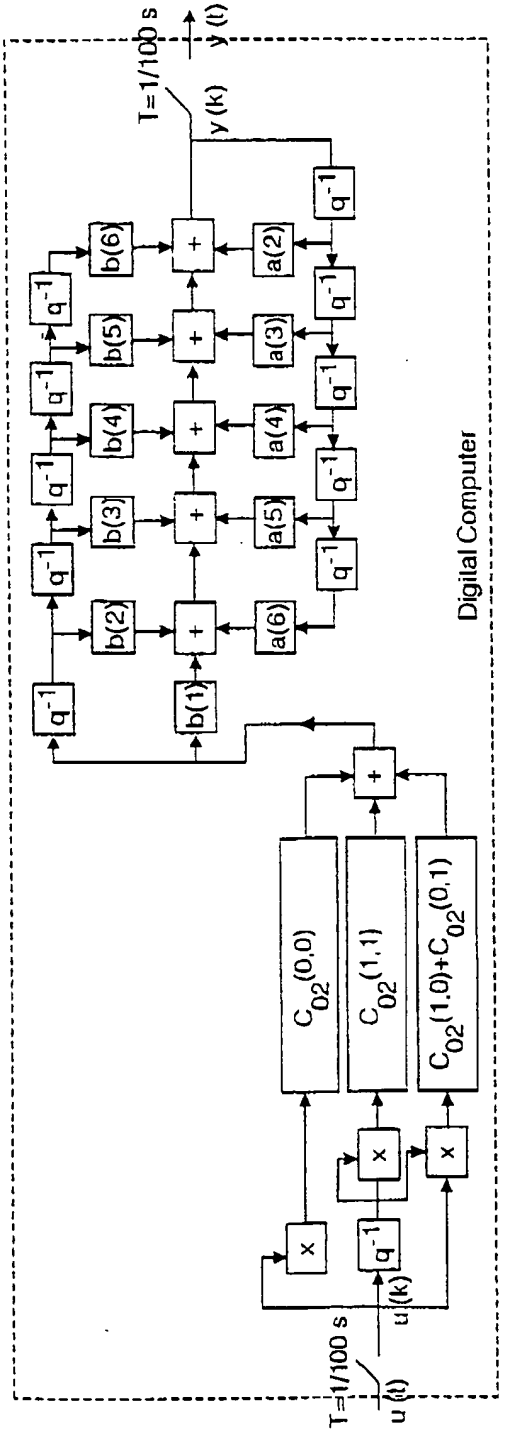
T=1/100 s
y(k)
y(t)
Digital Computer
b(6)
b(5)
b(4)
b(3)
b(2)
b(1)
a(2)
a(3)
a(4)
a(5)
a(6)
$q^{-1}$
$C_{02}(0,0)$
$C_{02}(1,1)$
$C_{02}(1.0)+C_{02}(0,1)$
u(k)
T=1/100 s
u(t)

Fig. 9

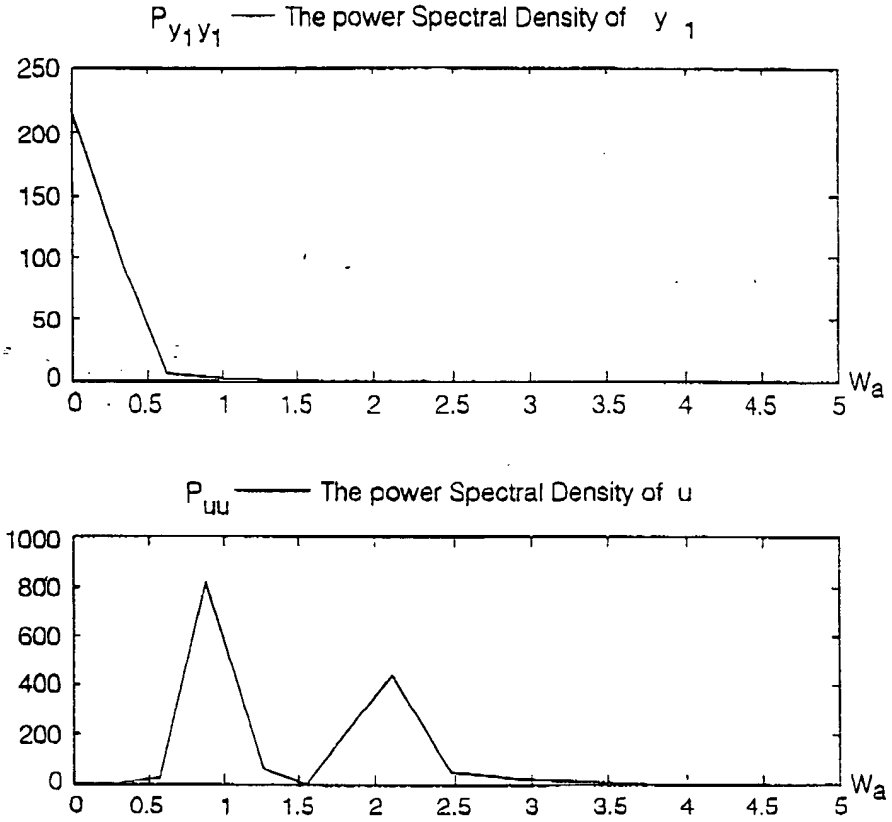
$P_{y_1 y_1}$ —— The power Spectral Density of $y_1$
250
200
150
100
50
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Wa
$P_{uu}$ —— The power Spectral Density of u
1000
800
600
400
200
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Wa

Fig. 10

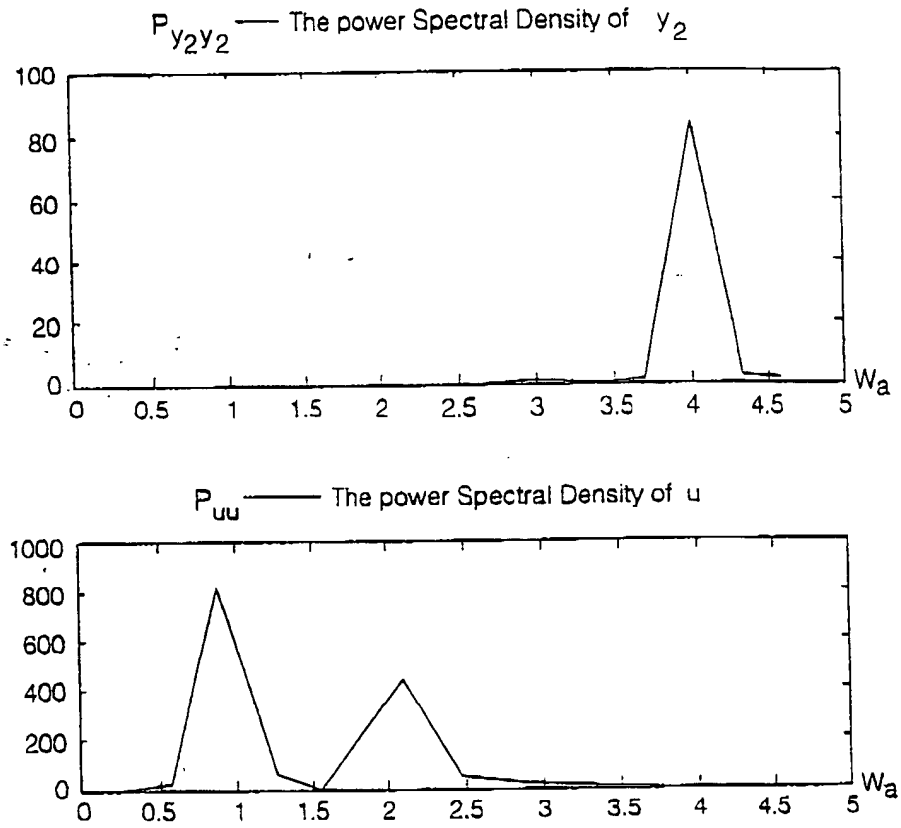
$P_{y_2y_2}$ —— The power Spectral Density of $y_2$
100
80
60
40
20
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Wa
$P_{uu}$ —— The power Spectral Density of u
1000
800
600
400
200
0
0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
Wa

Fig. 11

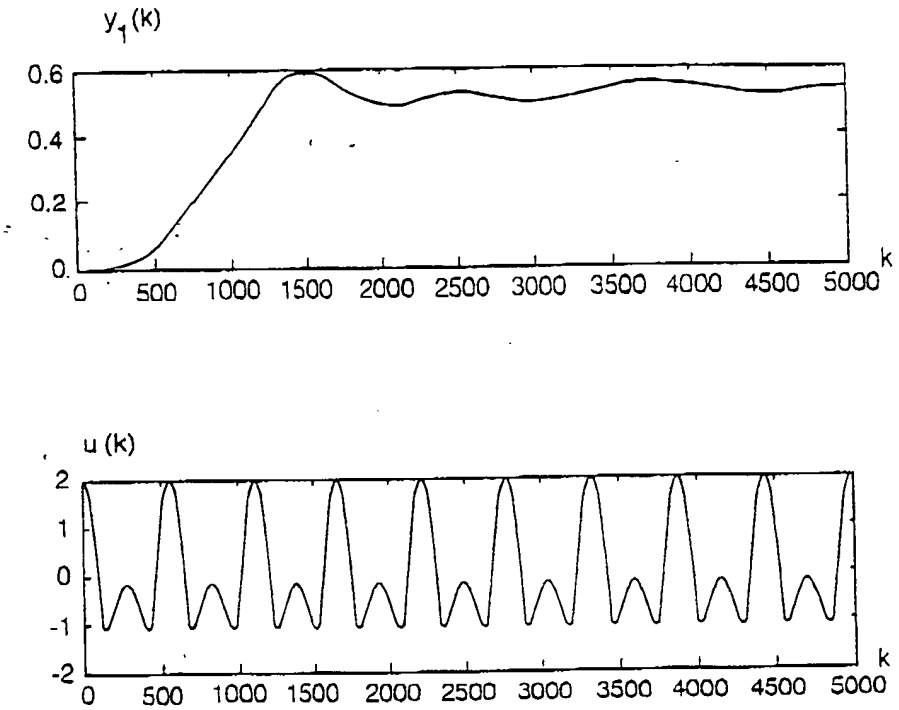
$y_1(k)$
0.6
0.4
0.2
0
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
k
u (k)
2
1
0
-1
-2
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
k

Fig. 12

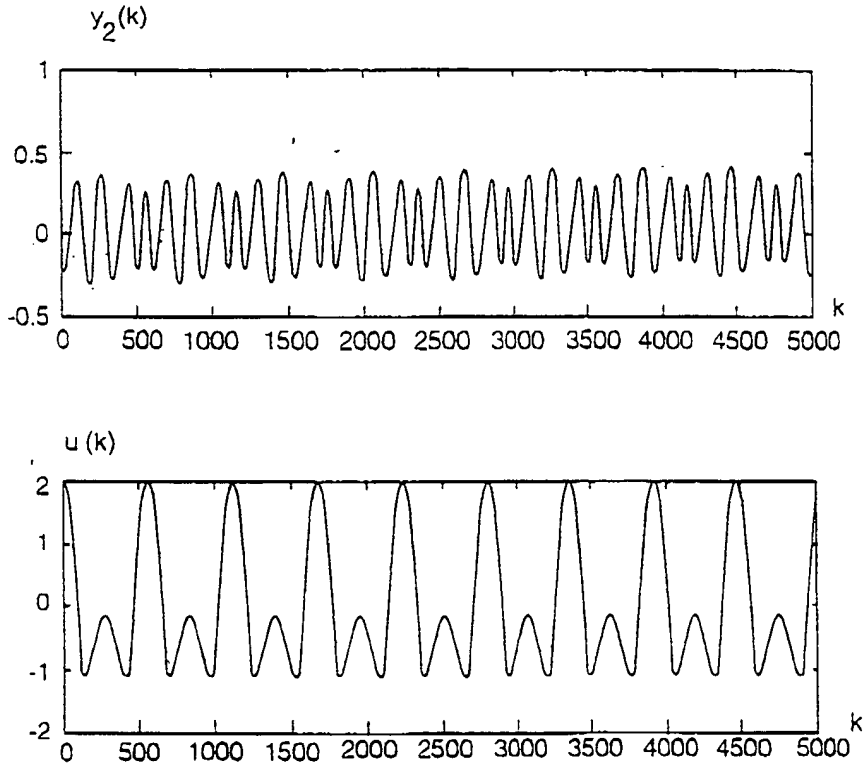
$y_2(k)$
1
0.5
0
-0.5
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
k
u (k)
2
1
0
-1
-2
0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000
k

Fig. 13

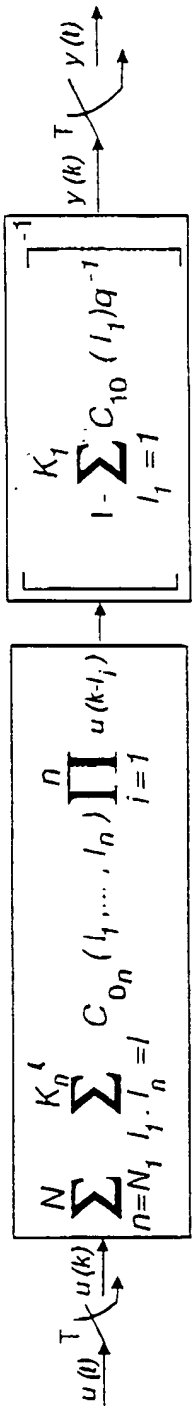
y(t)
y(k)
T
$\frac{K_1}{1-\sum_{l_1=1} C_{10}(l_1)q^{-1}}$
$\sum_{n=N_1}^{N} \frac{K_n'}{l_1 \cdots l_n} C_{0n}(l_1, \ldots, l_n) \prod_{i=1}^{n} u(k-l_i)$
u(k)
T
u(t)

Fig. 14

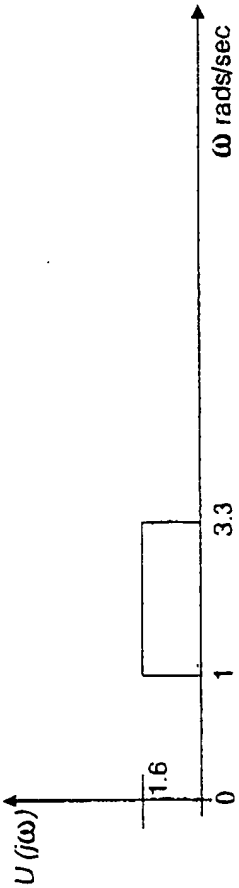
ω rads/sec
3.3
1
0
1.6
U(jω)

Fig. 15

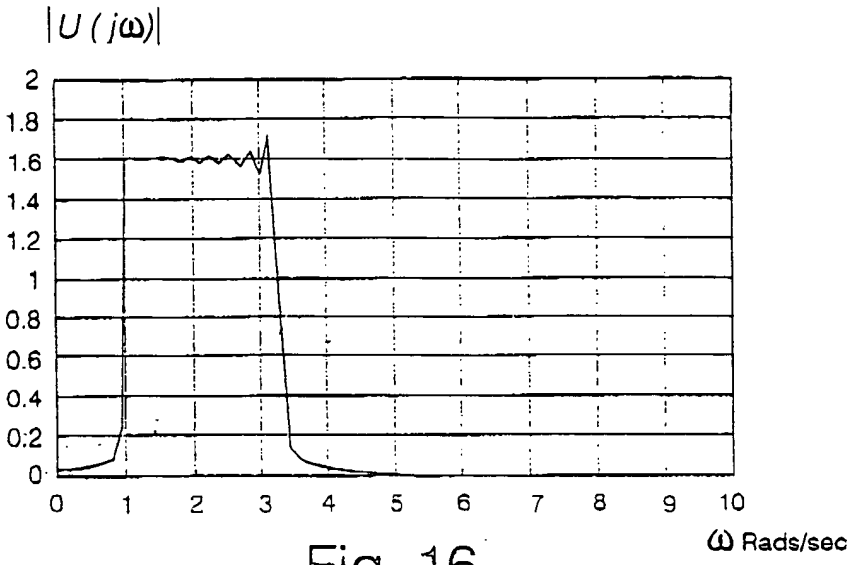


Fig. 16

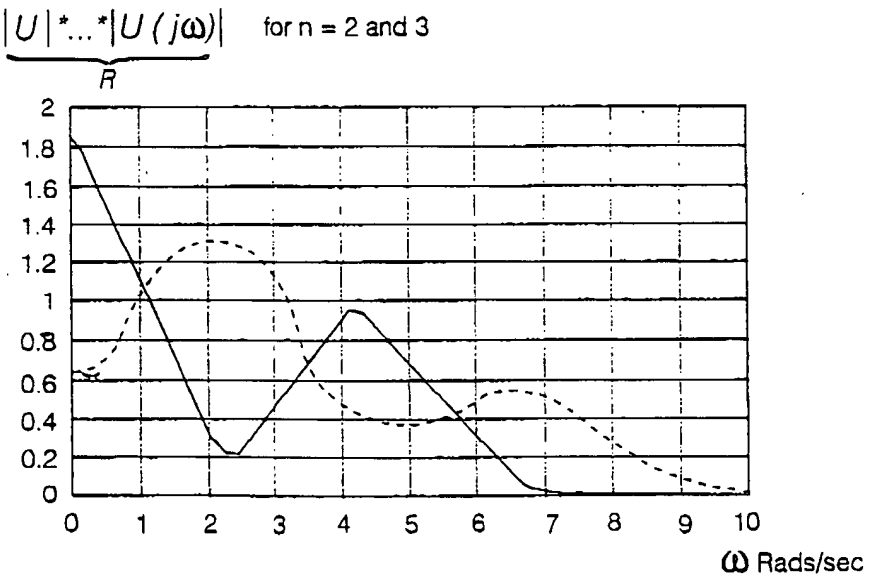


Fig. 17

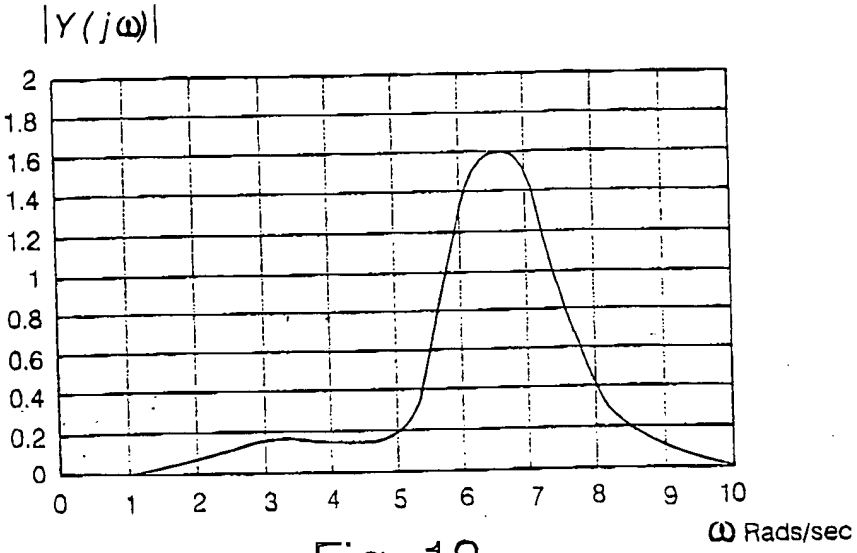


Fig. 18

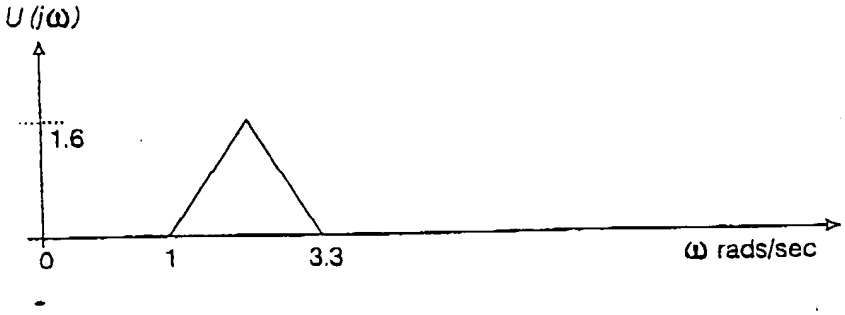


Fig. 19

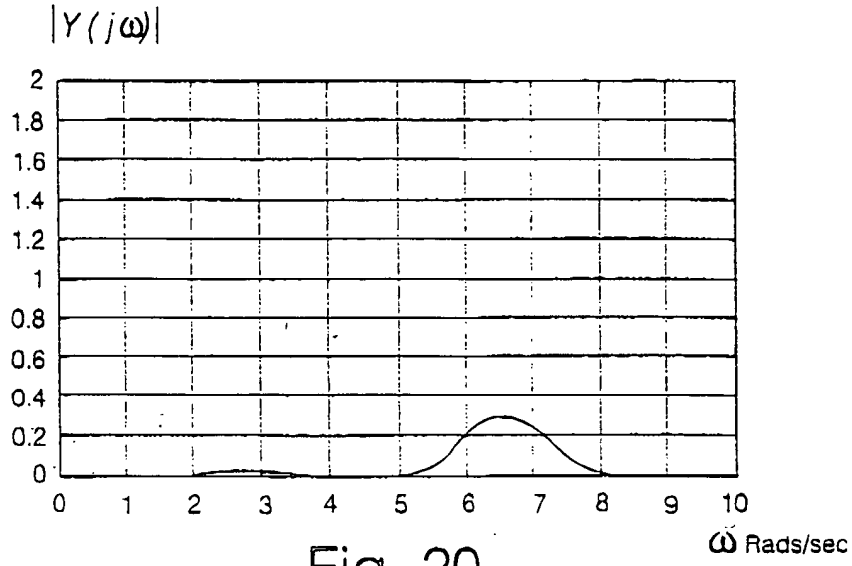


Fig. 20

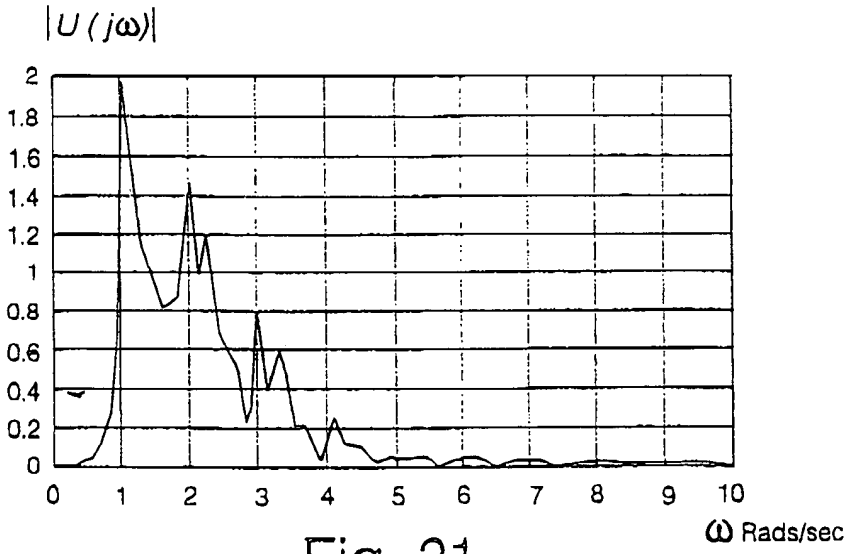


Fig. 21

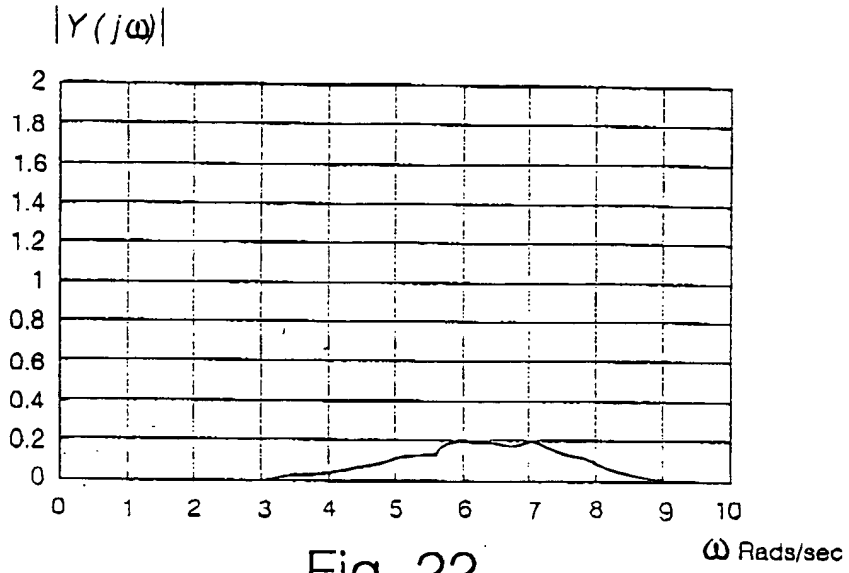


Fig. 22

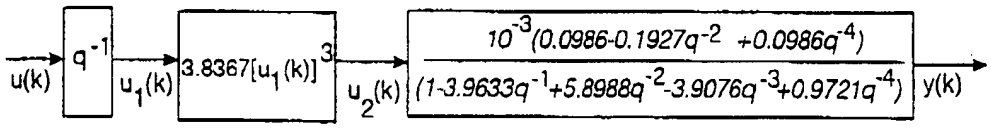


Fig. 23

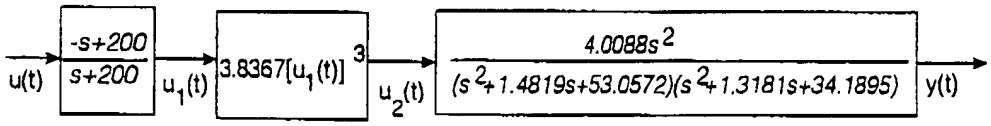


Fig. 24

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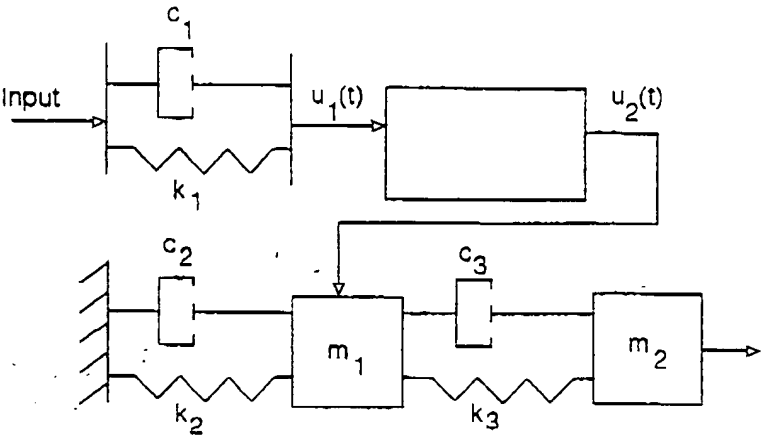


Fig. 25

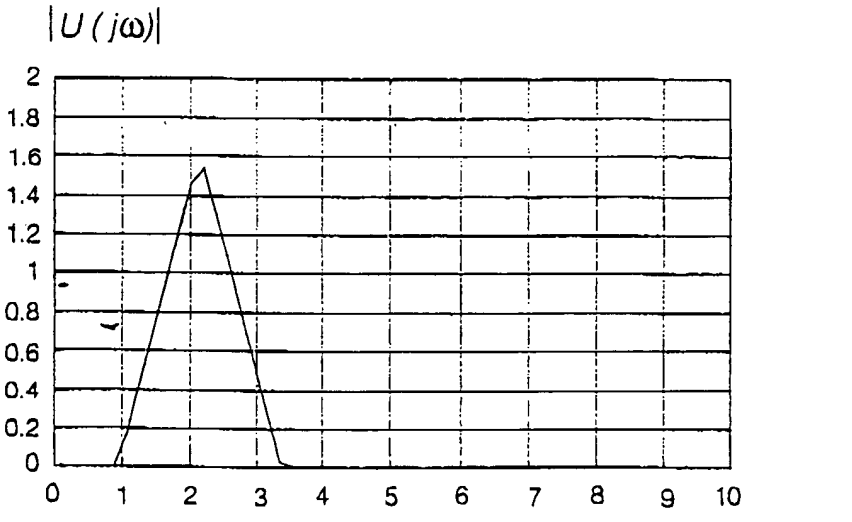


Fig. 26

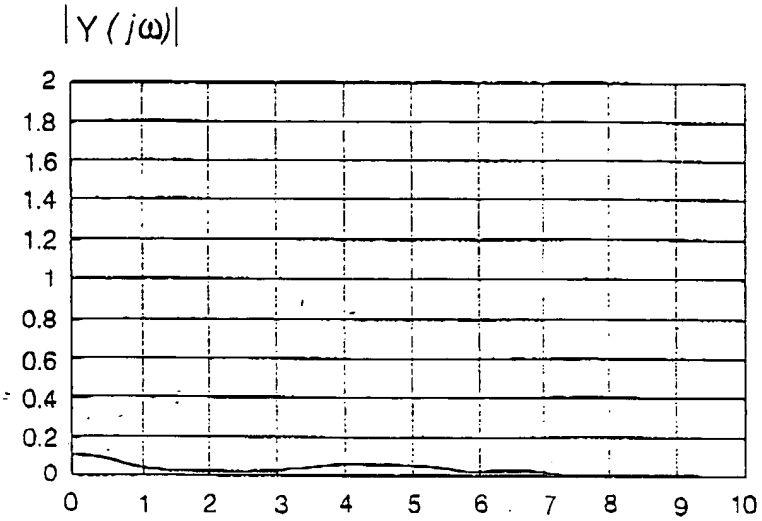
|Y(jω)|
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7 8 9 10
ω Rads/sec

Fig. 27

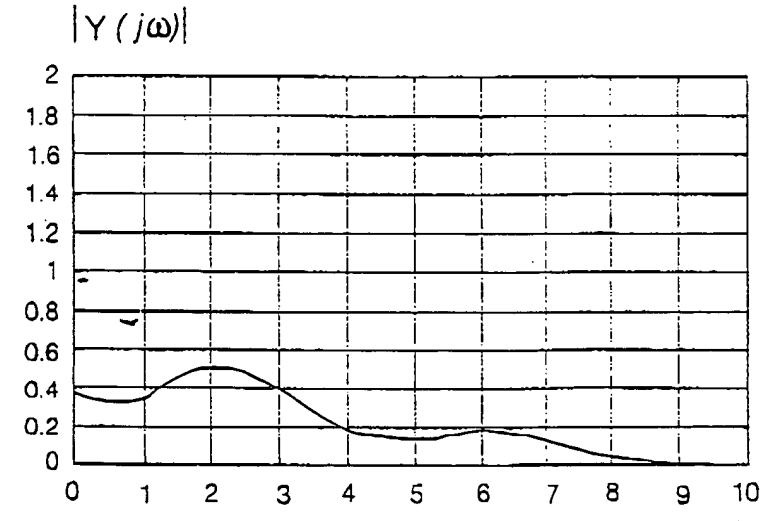
|Y(jω)|
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0 1 2 3 4 5 6 7 8 9 10
ω Rads/sec

Fig. 28

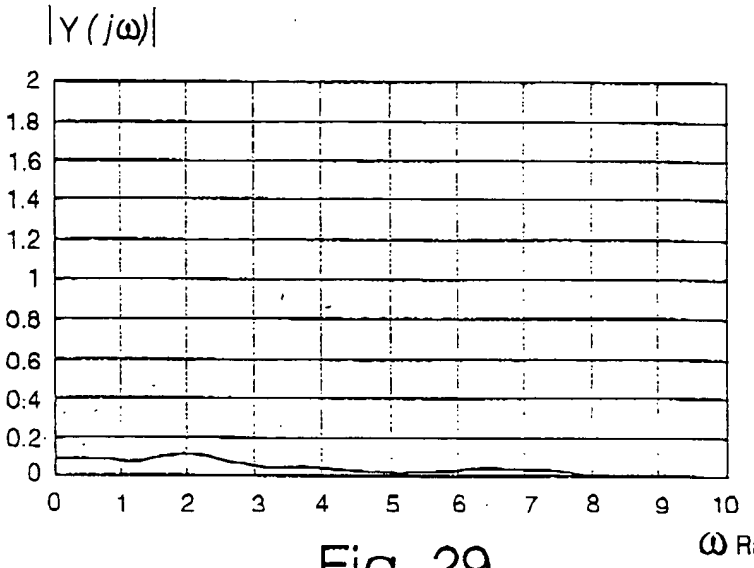


Fig. 29

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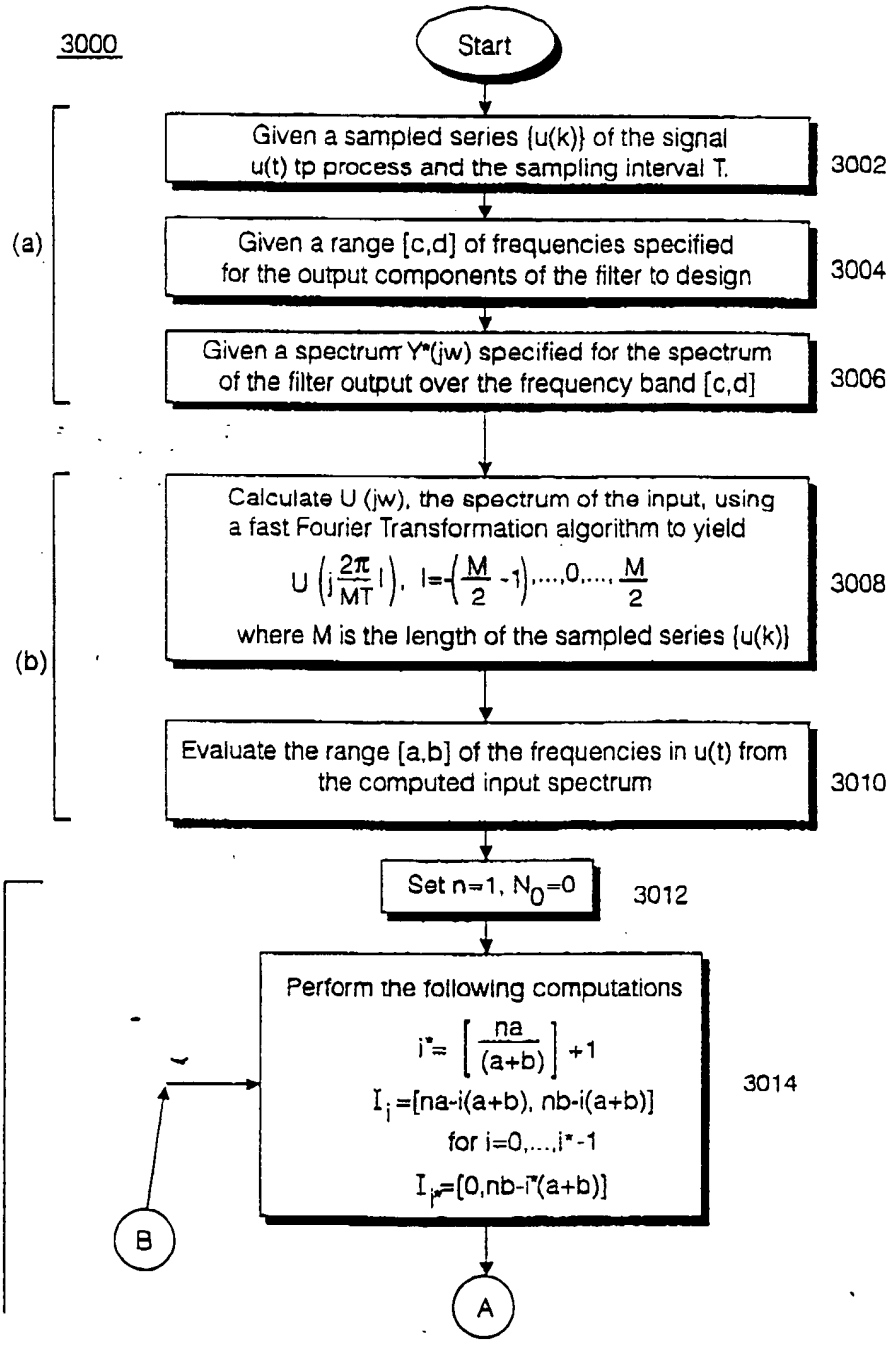


Fig. 30

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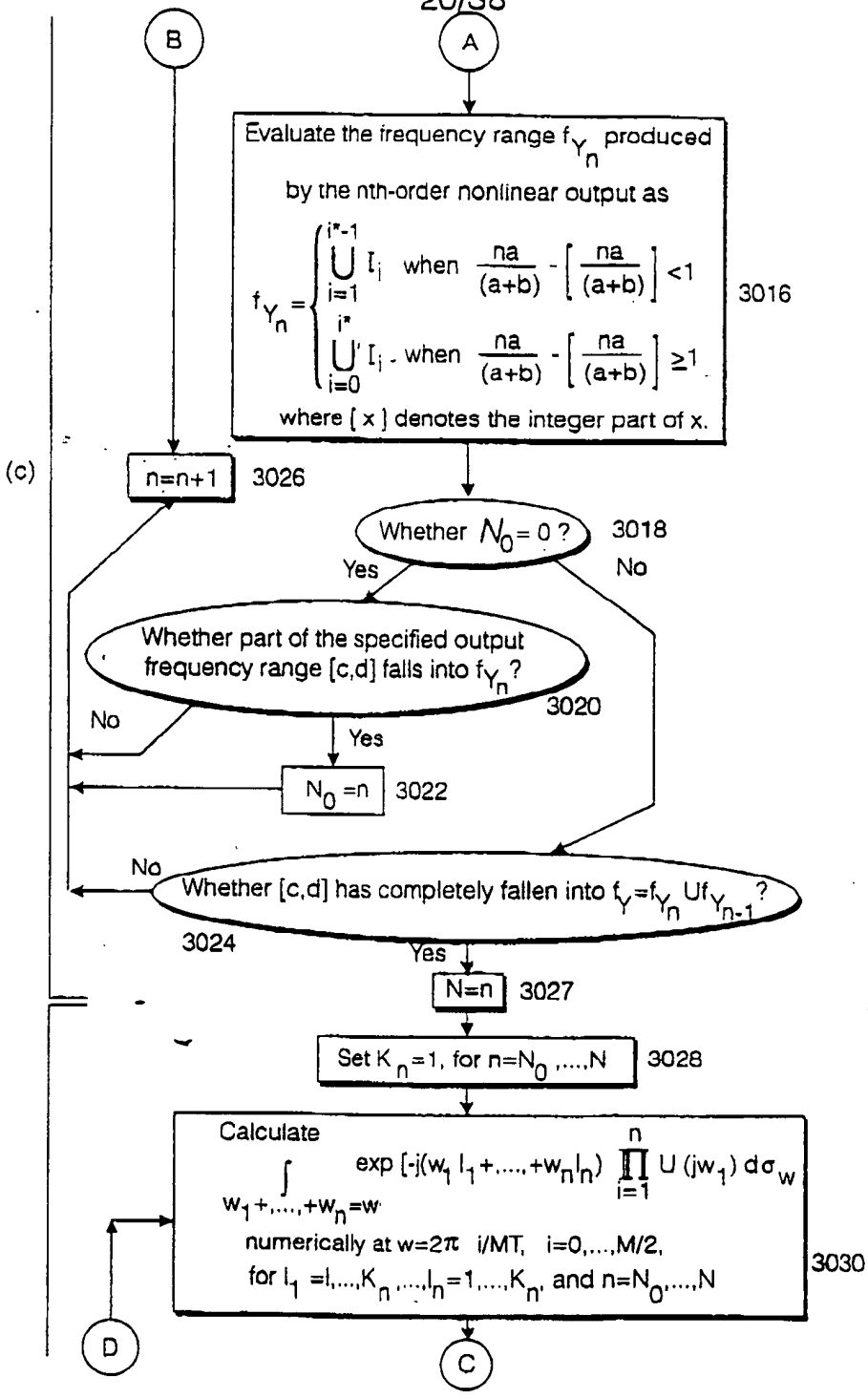
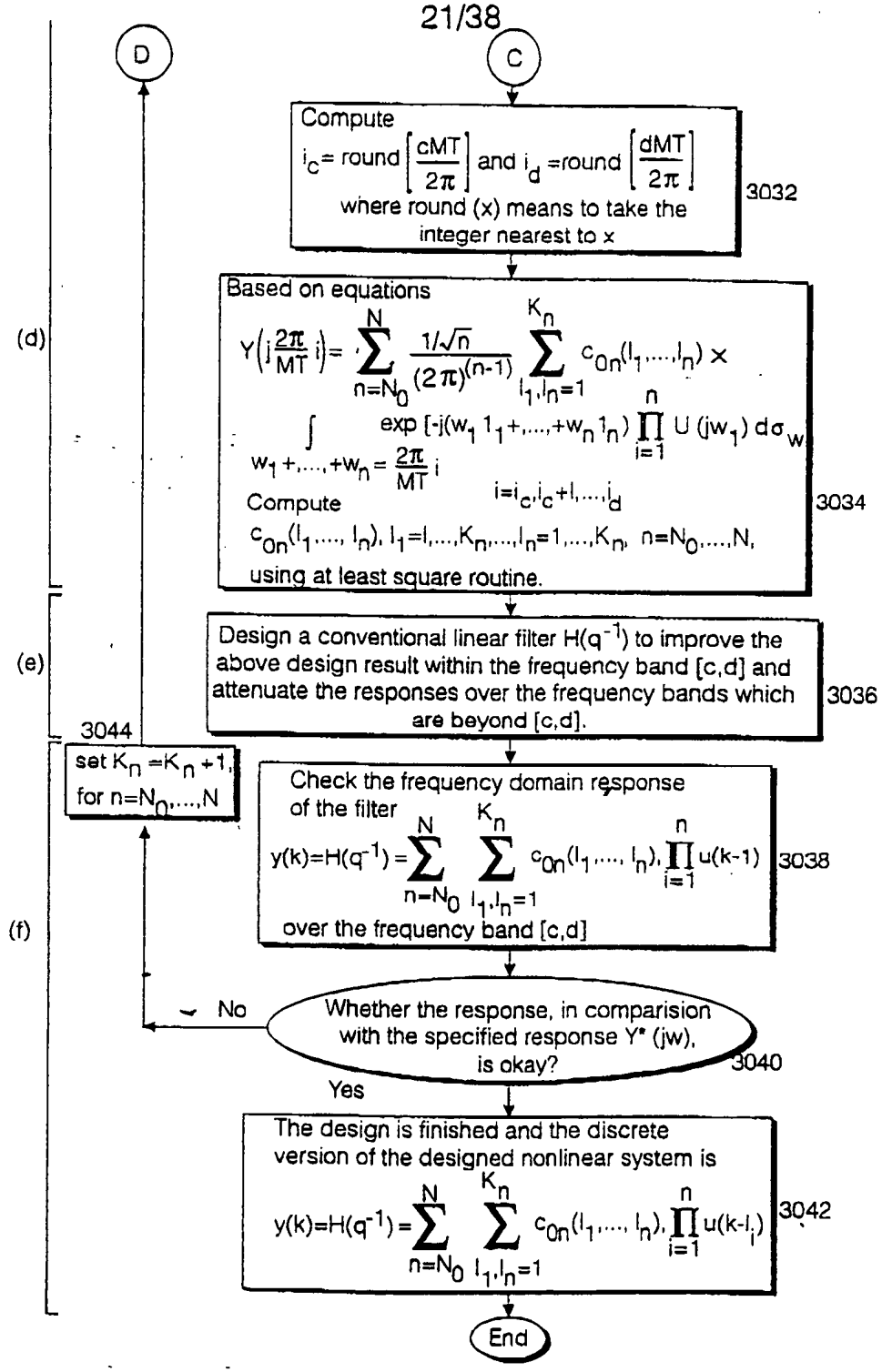



D
C
Compute
$i_c$= round $\left[\frac{cMT}{2\pi}\right]$ and $i_d$ =round $\left[\frac{dMT}{2\pi}\right]$
where round (x) means to take the integer nearest to x
3032
(d)
Based on equations
$Y\left(j\frac{2\pi}{MT}i\right)=\sum_{n=N_0}^{N}\frac{1/\sqrt{n}}{(2\pi)^{(n-1)}}\sum_{l_1,l_n=1}^{K_n}c_{0n}(l_1,\ldots,l_n)\times$
$\int_{w_1+,\ldots,+w_n=\frac{2\pi}{MT}i}\exp[-j(w_1 l_1+,\ldots,+w_n l_n)\prod_{i=1}^{n}U(jw_1)\,d\sigma_w$
Compute $i=i_c,i_c+l,\ldots,i_d$
$c_{0n}(l_1,\ldots,l_n)$, $l_1=l,\ldots,K_n,\ldots,l_n=1,\ldots,K_n$, $n=N_0,\ldots,N$,
using at least square routine.
3034
(e)
Design a conventional linear filter $H(q^{-1})$ to improve the above design result within the frequency band [c,d] and attenuate the responses over the frequency bands which are beyond [c,d].
3036
3044
set $K_n=K_n+1$, for $n=N_0,\ldots,N$
(f)
Check the frequency domain response of the filter
$y(k)=H(q^{-1})=\sum_{n=N_0}^{N}\sum_{l_1,l_n=1}^{K_n}c_{0n}(l_1,\ldots,l_n)\prod_{i=1}^{n}u(k-1)$
over the frequency band [c,d]
3038
No
Whether the response, in comparision with the specified response Y* (jw), is okay?
3040
Yes
The design is finished and the discrete version of the designed nonlinear system is
$y(k)=H(q^{-1})=\sum_{n=N_0}^{N}\sum_{l_1,l_n=1}^{K_n}c_{0n}(l_1,\ldots,l_n)\prod_{i=1}^{n}u(k-l_i)$
3042
End

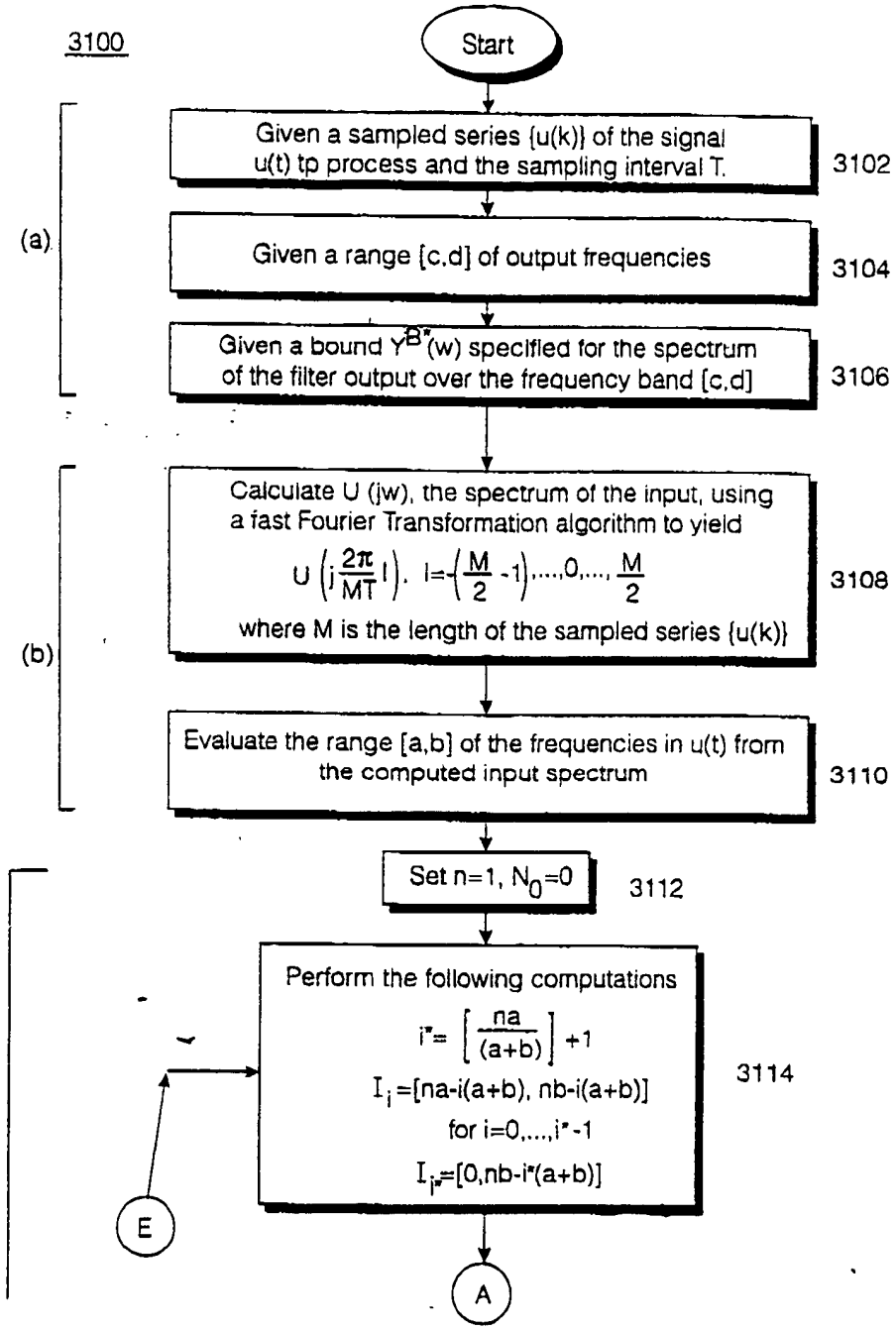
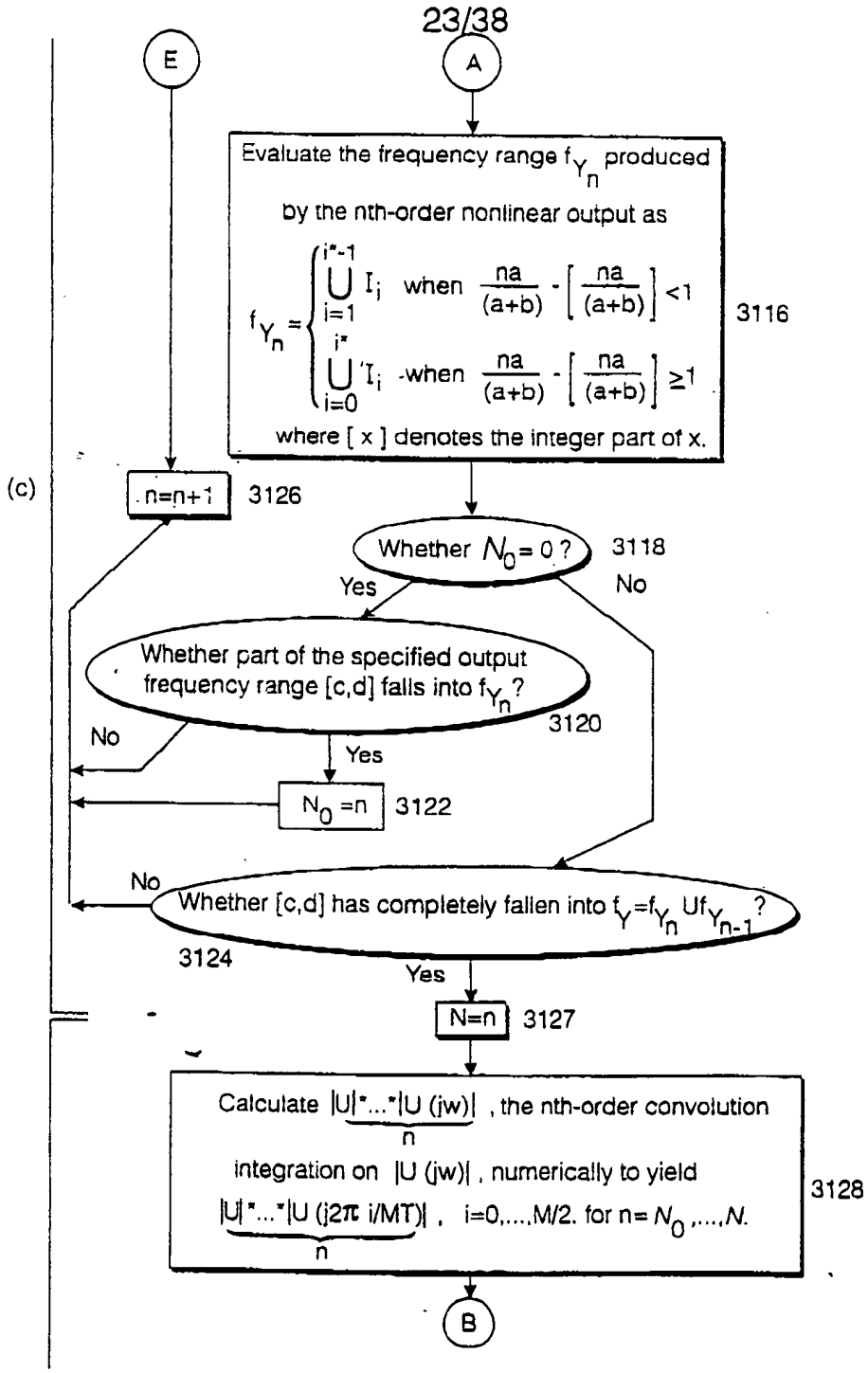

3100
Start
(a)
Given a sampled series {u(k)} of the signal u(t) tp process and the sampling interval T.
3102
Given a range [c,d] of output frequencies
3104
Given a bound $Y^{B*}(w)$ specified for the spectrum of the filter output over the frequency band [c,d]
3106
(b)
Calculate U (jw), the spectrum of the input, using a fast Fourier Transformation algorithm to yield
$U\left(j\frac{2\pi}{MT}l\right)$, $l=-\left(\frac{M}{2}-1\right),\ldots,0,\ldots,\frac{M}{2}$
where M is the length of the sampled series {u(k)}
3108
Evaluate the range [a,b] of the frequencies in u(t) from the computed input spectrum
3110
Set n=1, $N_0=0$
3112
Perform the following computations
$i^*=\left[\frac{na}{(a+b)}\right]+1$
$I_i=[na-i(a+b),\ nb-i(a+b)]$
for $i=0,\ldots,i^*-1$
$I_{i^*}=[0,nb-i^*(a+b)]$
3114
E
A

Fig. 31


E
A
Evaluate the frequency range $f_{Y_n}$ produced by the nth-order nonlinear output as
$f_{Y_n} = \begin{cases} \bigcup_{i=1}^{i^*-1} I_i & \text{when } \frac{na}{(a+b)} - \left[\frac{na}{(a+b)}\right] < 1 \\ \bigcup_{i=0}^{i^*} I_i & \text{when } \frac{na}{(a+b)} - \left[\frac{na}{(a+b)}\right] \geq 1 \end{cases}$
where [ x ] denotes the integer part of x.
3116
(c)
n=n+1
3126
Whether $N_0 = 0$ ?
3118
Yes
No
Whether part of the specified output frequency range [c,d] falls into $f_{Y_n}$ ?
3120
No
Yes
$N_0 = n$
3122
No
Whether [c,d] has completely fallen into $f_Y = f_{Y_n} U f_{Y_{n-1}}$ ?
3124
Yes
N=n
3127
Calculate $\underbrace{|U|*...*|U(jw)|}_{n}$, the nth-order convolution integration on |U (jw)|, numerically to yield $\underbrace{|U|*...*|U(j2\pi i/MT)|}_{n}$, i=0,...,M/2. for n= $N_0$,...,N.
3128
B

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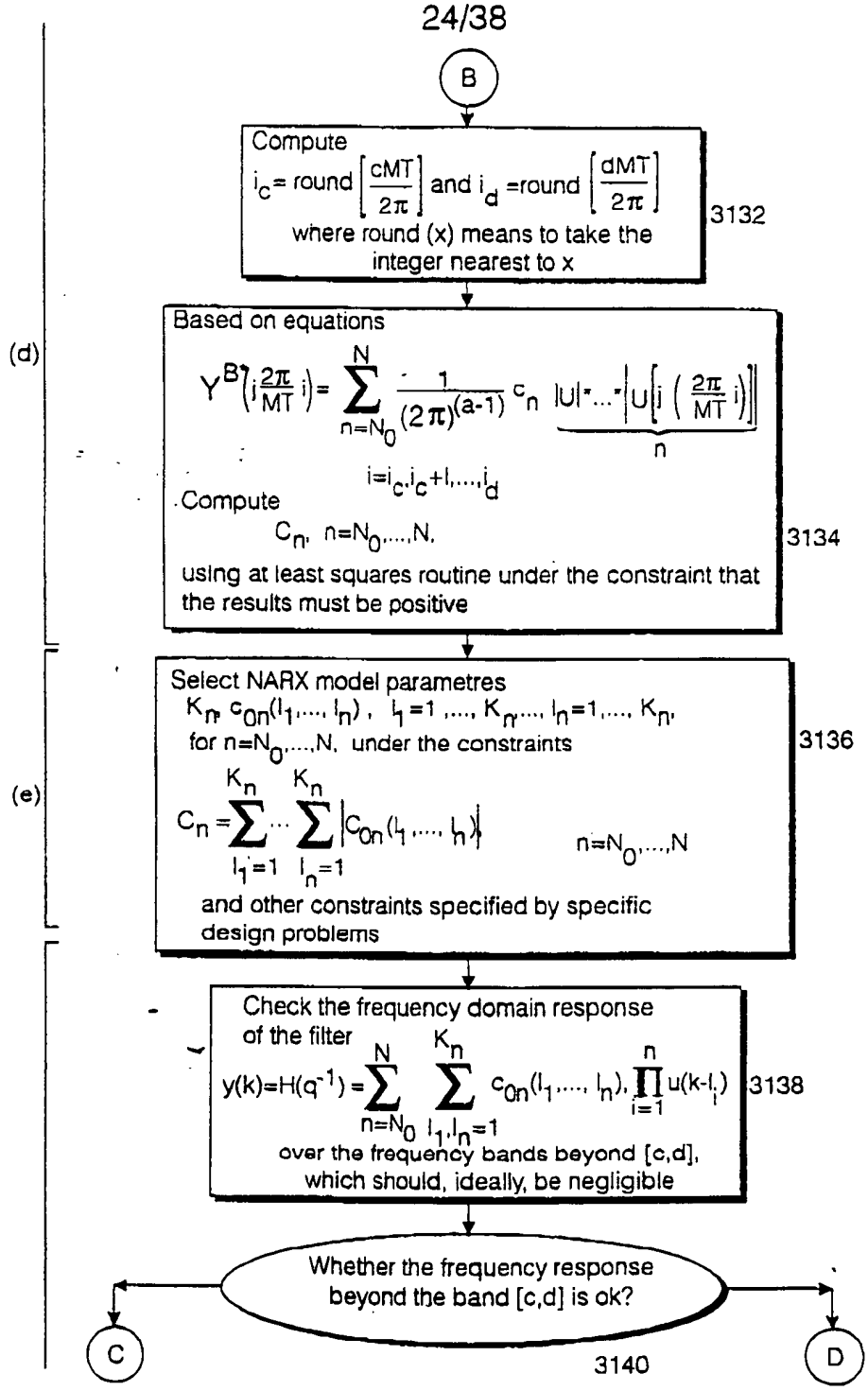

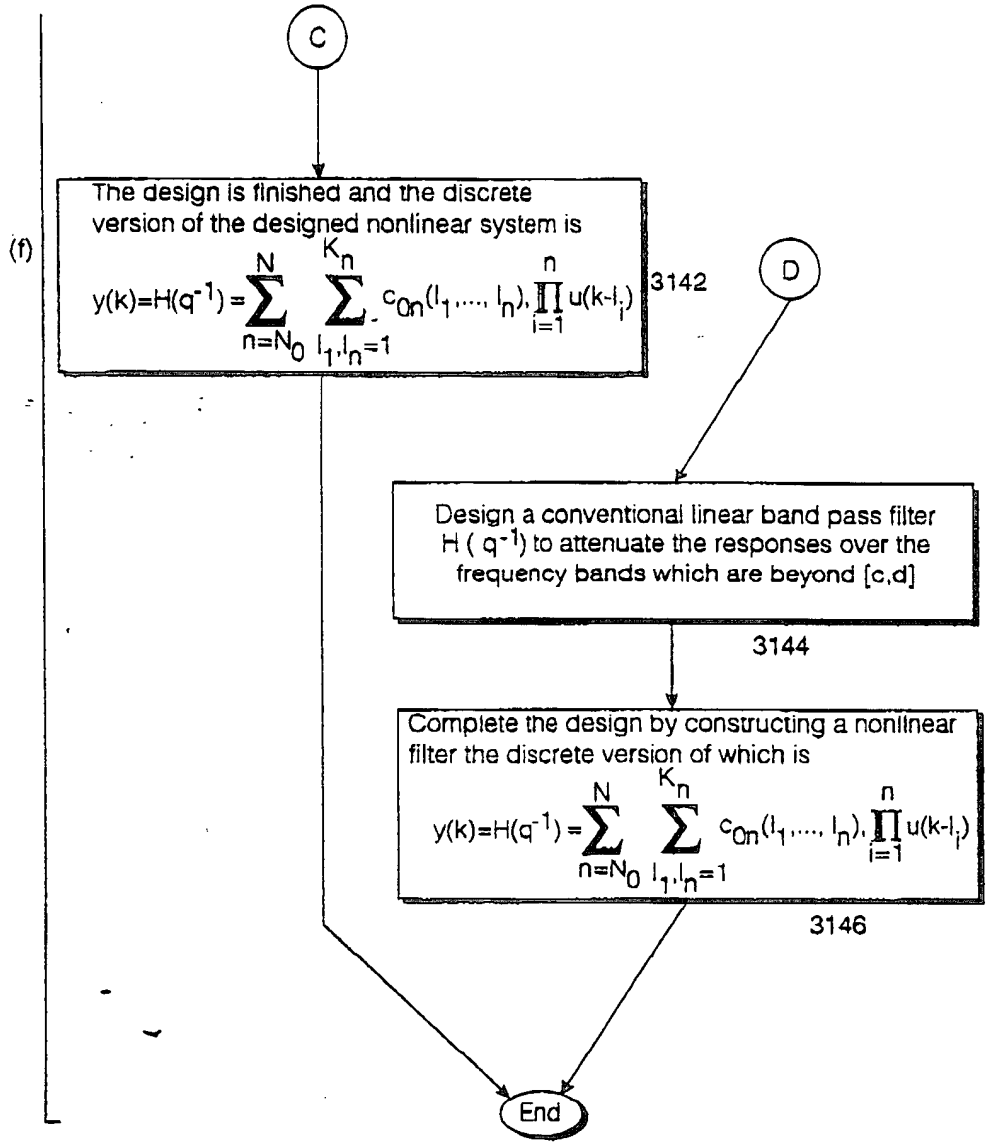
C
(f)
The design is finished and the discrete version of the designed nonlinear system is
$y(k)=H(q^{-1})=\sum_{n=N_0}^{N}\sum_{l_1,l_n=1}^{K_n} c_{0n}(l_1,\ldots,l_n)\prod_{i=1}^{n}u(k-l_i)$
3142
D
Design a conventional linear band pass filter $H(q^{-1})$ to attenuate the responses over the frequency bands which are beyond [c,d]
3144
Complete the design by constructing a nonlinear filter the discrete version of which is
$y(k)=H(q^{-1})=\sum_{n=N_0}^{N}\sum_{l_1,l_n=1}^{K_n} c_{0n}(l_1,\ldots,l_n)\prod_{i=1}^{n}u(k-l_i)$
3146
End

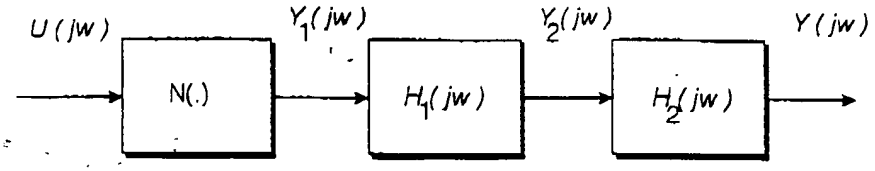


Fig. 32

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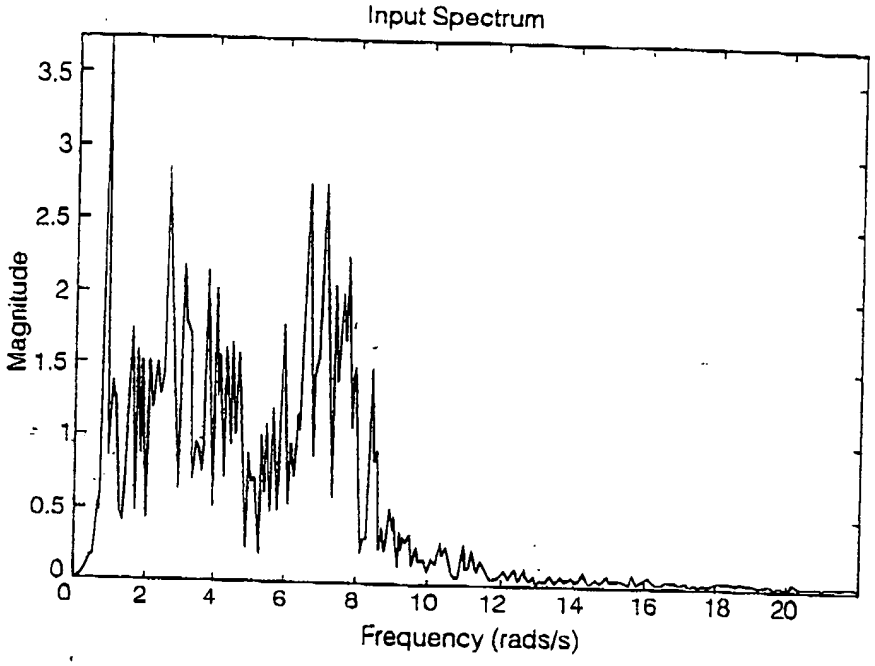


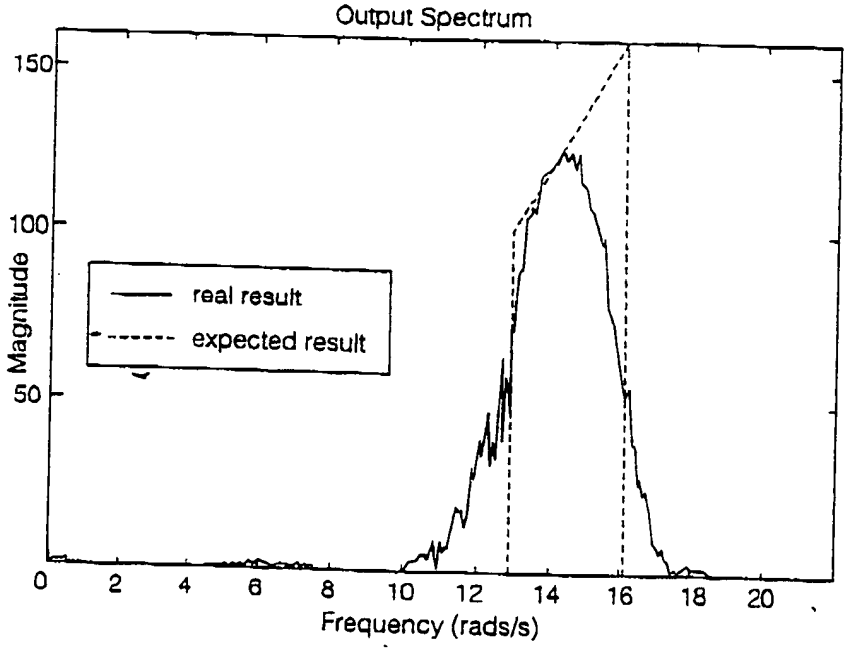


Fig. 33

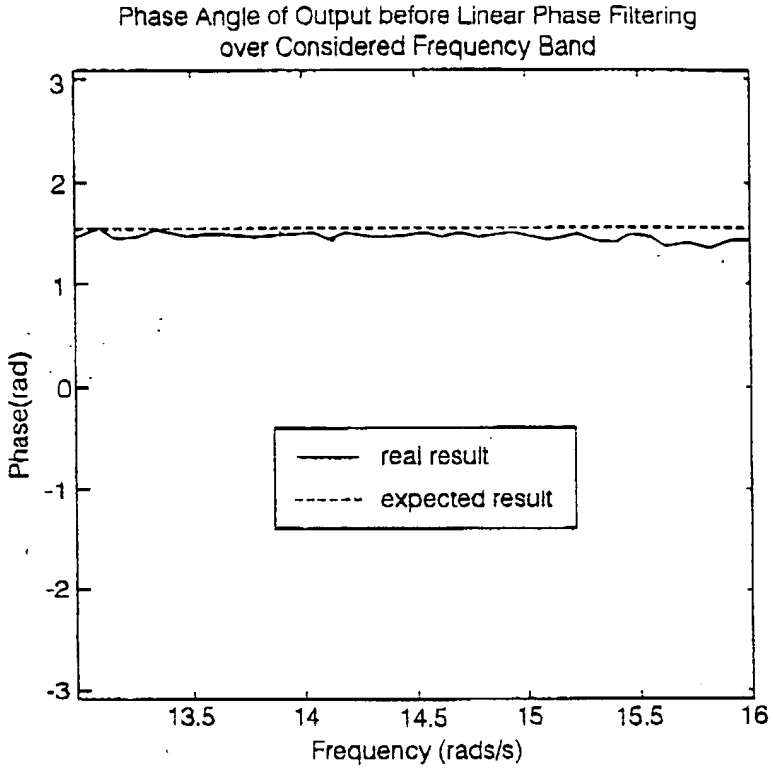
Phase Angle of Output before Linear Phase Filtering
over Considered Frequency Band
Phase(rad)
Frequency (rads/s)
real result
expected result
3
2
1
0
-1
-2
-3
13.5
14
14.5
15
15.5
16

Fig. 34

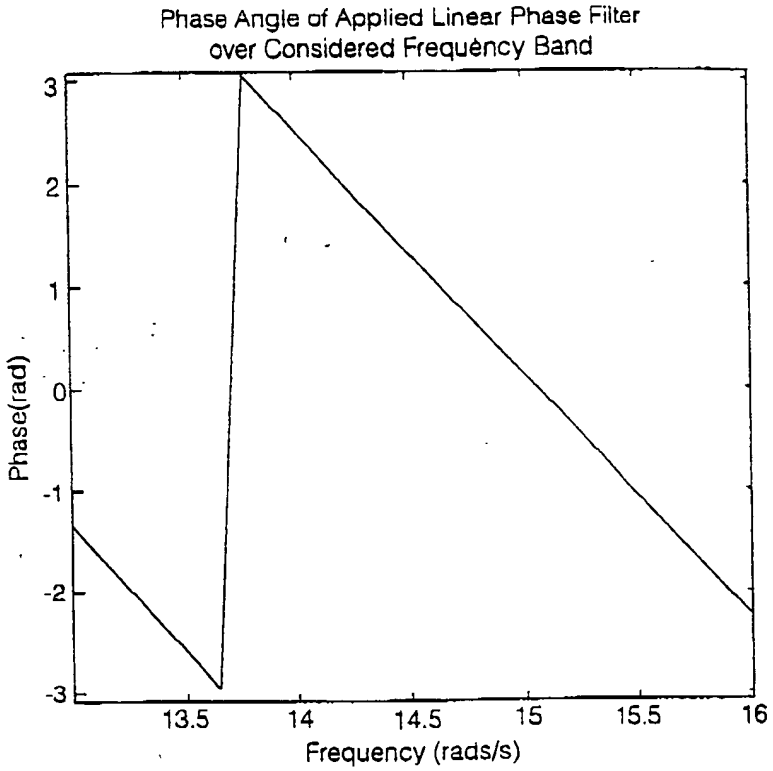
Phase Angle of Applied Linear Phase Filter
over Considered Frequency Band
Phase(rad)
3
2
1
0
-1
-2
-3
13.5
14
14.5
15
15.5
16
Frequency (rads/s)

Fig. 35

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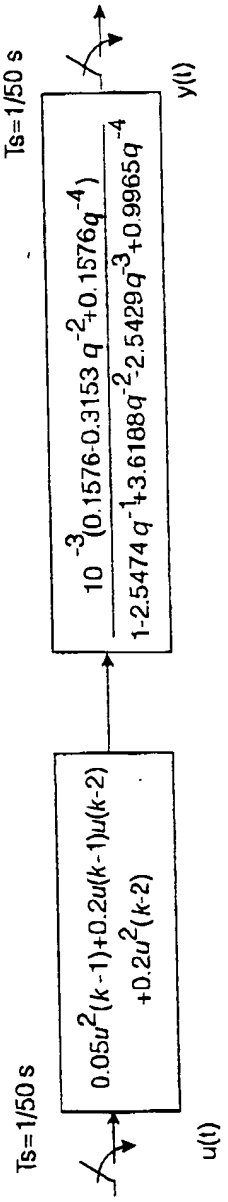


Fig. 36

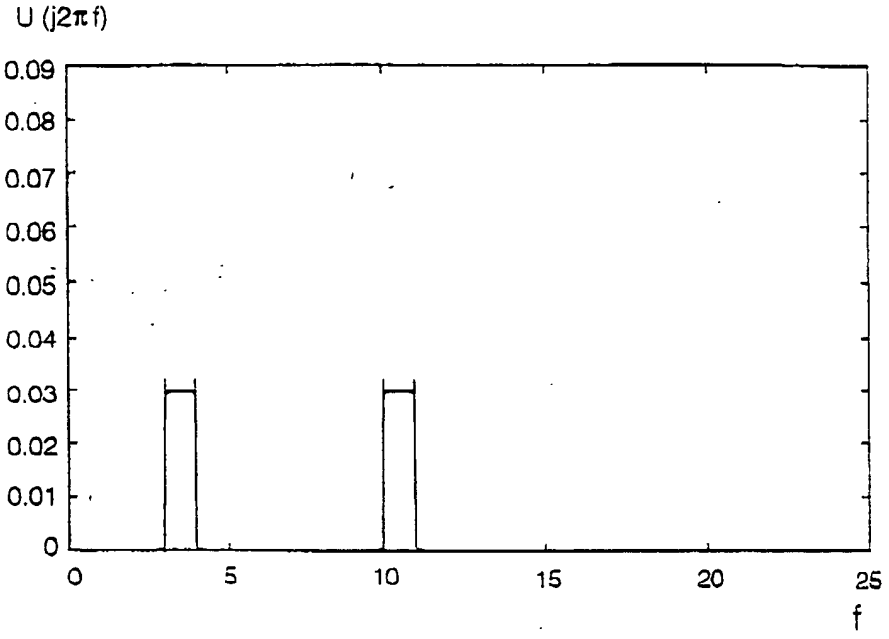


Fig. 37

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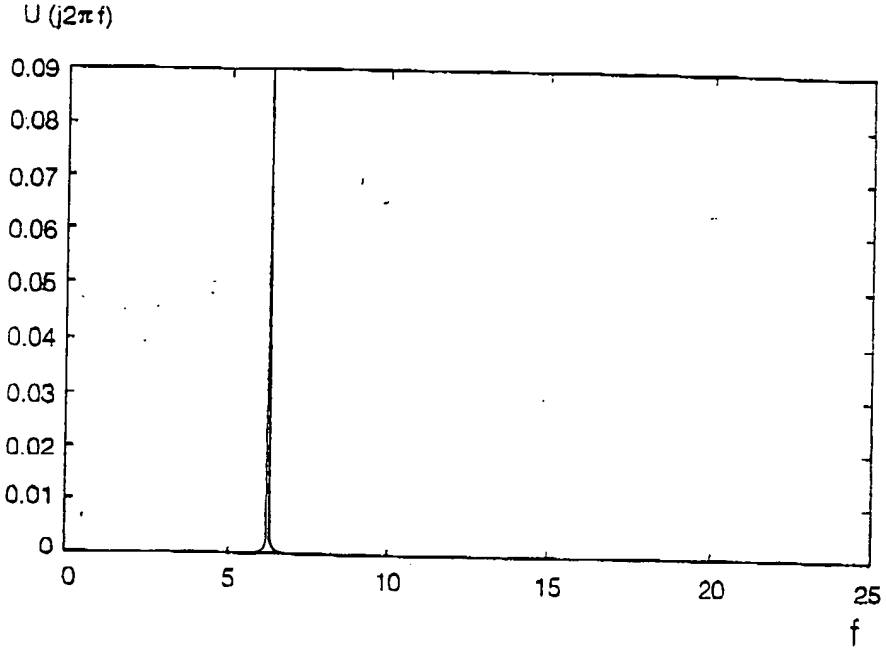


Fig. 38

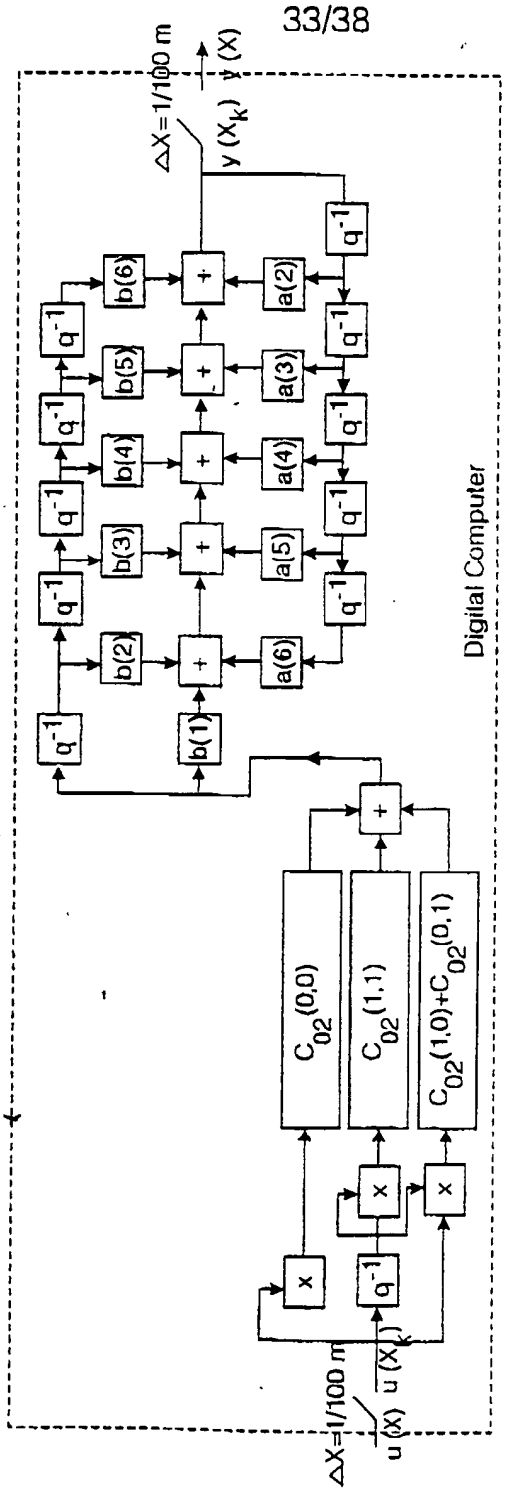
y (X)
ΔX=1/100 m
y (X_k)
Digital Computer
q^-1
b(6)
b(5)
b(4)
b(3)
b(2)
b(1)
a(2)
a(3)
a(4)
a(5)
a(6)
+
x
C_02(0,0)
C_02(1,1)
C_02(1,0)+C_02(0,1)
u (X)
u (X_k)
ΔX=1/100 m

Fig. 39

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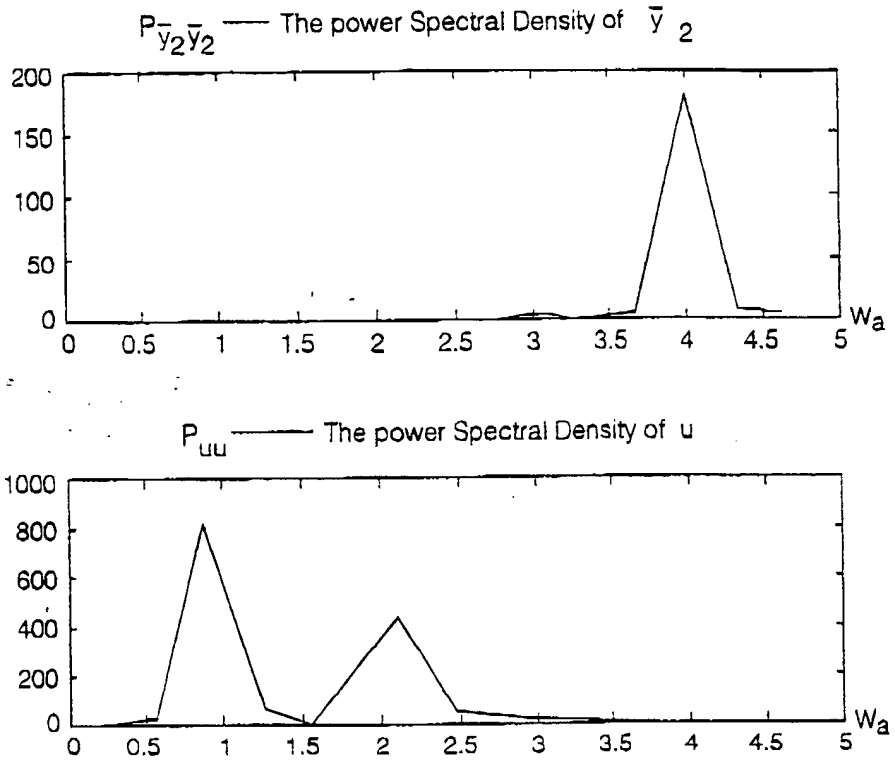


Fig. 40

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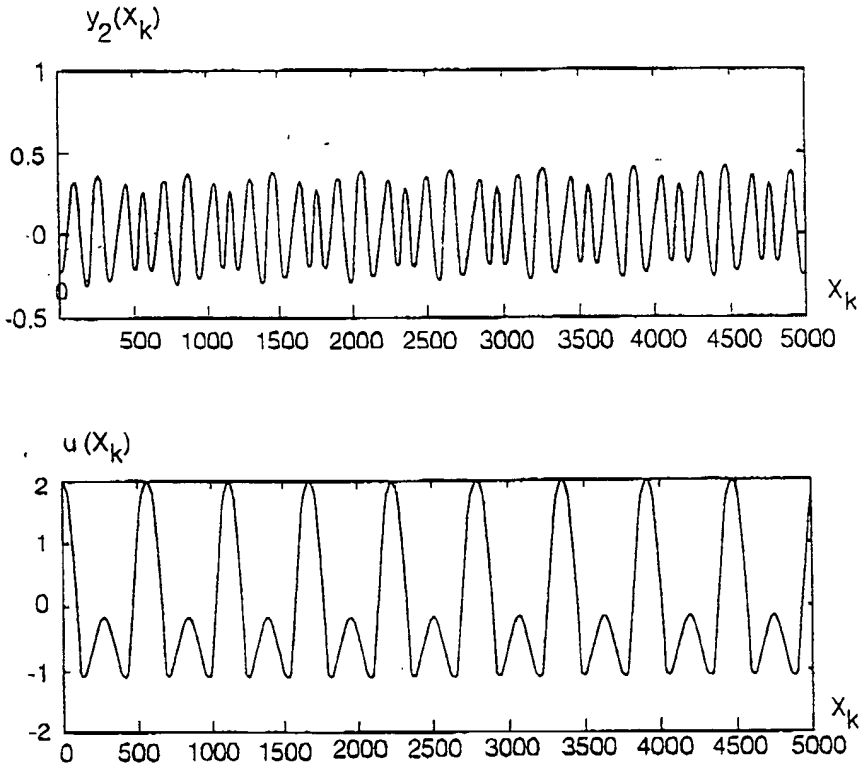


Fig. 41

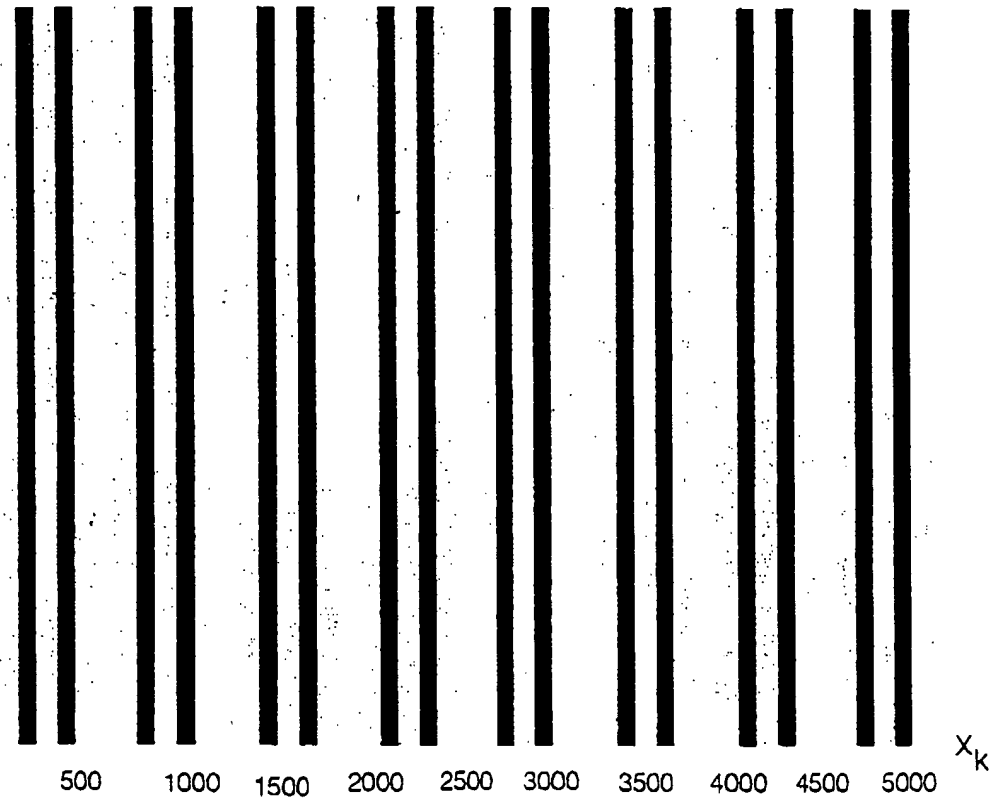


Fig. 42

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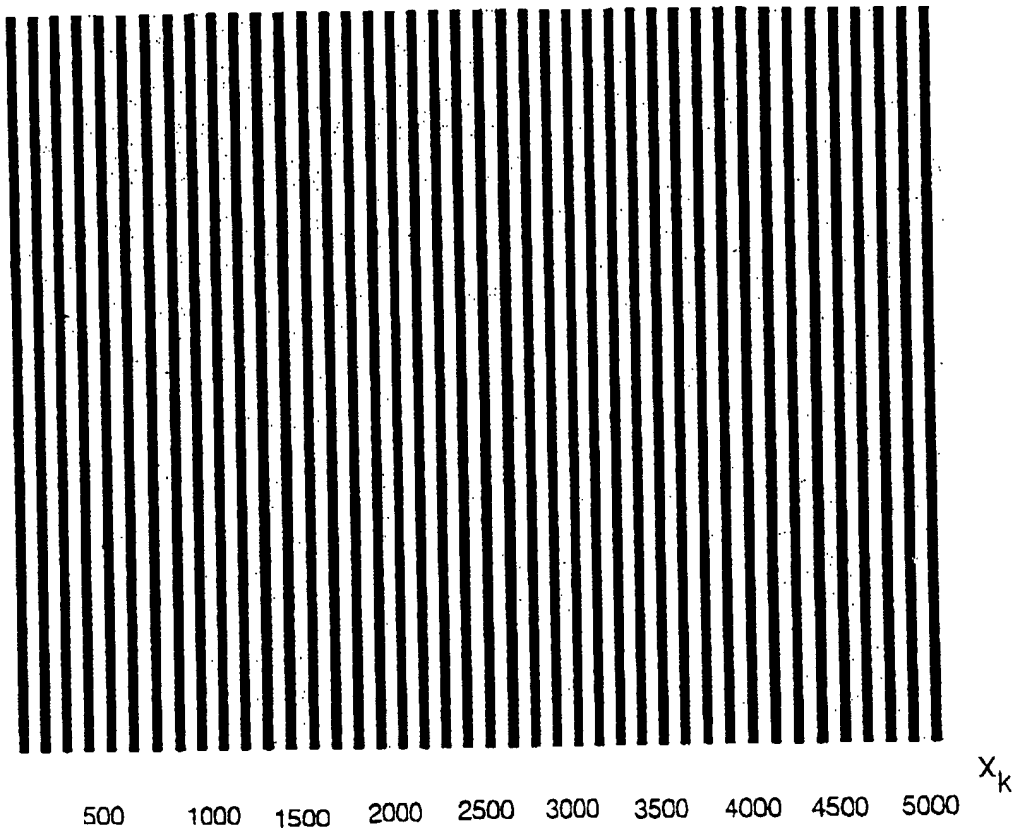


Fig. 43

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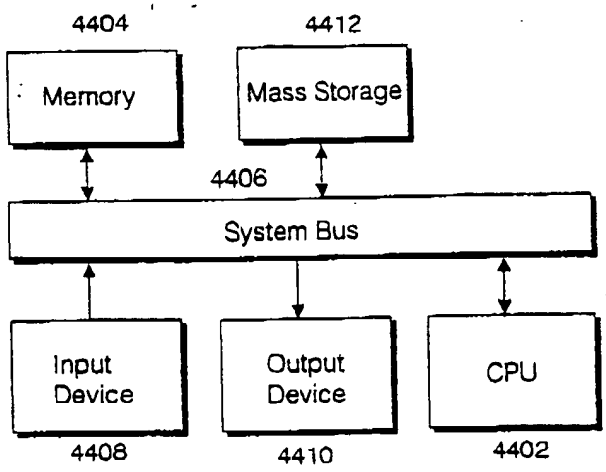


Fig. 44